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ABSTRACT

In Study I, reading disability children were tested on perceptual encoding speed with a visual reaction-time task requiring same-different judgements. Performance of disabled children deteriorated as testing progressed, and recovered after a rest. In Study II, the poor readers of Study I were rated by their teachers on a 15-item inventory of abnormal motor behavior. Reaction time from initial trials of the test given in Study I was significantly correlated with the motor coordination factor on the inventory. In Study III, hyperactive boys taking methylphenidate medication and hyperactive boys whose medication was temporarily discontinued were tested. Reaction time on early trials was not significantly different for boys in the on-medication and off-medication groups. As testing progressed, reaction times of normal boys and boys taking medication remained fairly stable, while the performance of hyperactive boys not taking medication declined. (Author/CB)

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PERCEPTUAL-SPEED DEFICIT IN READING-DISABILITY CHILDREN

August 1972

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

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In Study I, reading-disability and normal children were compared on perceptual encoding speed with a visual reaction-time task requiring same-different judgements. On initial trials the disabled group was slower than the normal group. In addition, the performance of disabled children deteriorated more than that of normal children as testing progressed, and recovered more after a rest (reminiscence). In Study II, the poor readers of Study I were rated by their teachers on a 15-item inventory of abnormal motor behavior. A factor analysis of teachers' ratings yielded 3 factors interpreted as Activity Level, Attention Span, and Motor Coordination. Reaction time from initial trials of the test given in Study I was significantly correlated with the Motor Coordination factor. Reminiscence was significantly correlated with the Attention Span factor. In Study III, hyperactive boys taking methylphenidate medication, hyperactive boys whose medication was temporarily discontinued, and normal boys were tested. Reaction time on early trials was not significantly different for boys in the on-medication and off-medication groups; however, both hyperactive groups were slower than the normal group. As testing progressed, reaction times of normal boys and boys taking medication remained fairly stable, while the performance of hyperactive boys not taking medication declined.

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Preface

The author wishes to acknowledge his collaboration in Study II and Study III with Lawrence Greenberg, M.D., School of Medicine, University of California, Davis. In addition, Dr. Jimmy Scott, School of Medicine, and John Hopwood, Department of Education, University of California, Davis, collaborated in Study III.

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Contents

Summary 1

Study I 3
Introduction
Method
Results and Discussion

Study II 6
Introduction
Method
Results and Discussion

Study III 9
Introduction
Method
Results and Discussion

Conclusions 12

References 14

Table 1 16
Rotated Factor Loadings and Communalities ($\underline{h}^2$)

Table 2 17
Correlations of Factor and Item Scores with Reaction-Time Scores

Table 3 18
Mann-Whitney Tests of Drug Effects

Figure 1 19
Mean reaction times for Study I, Blocks 1 through 6.

Figure 2 20
Mean reaction times for Study III, Blocks 1 through 6.

Summary

Some children, although they appear to have adequate or even high intelligence, fail to achieve normal reading skill during the elementary-school years. The purpose of the following studies was to evaluate perceptual encoding speed as a factor contributing to the problem of these children. In addition, methylphenidate, a drug commonly used in the treatment of childhood hyperactivity, was evaluated for its effect on response encoding speed.

In these studies, a visual reaction-time test was used to measure response encoding speed. The test required that a visual display be encoded into a two-choice motor response.

In Study I, children of poor and normal reading ability were matched on age, IQ, and sex. Mean reaction times of these groups differed on two components. The poor readers were slower than the normal readers from the very beginning of the test. In addition, the performance of poor readers deteriorated more than that of normal readers as testing progressed, and recovered more after a rest (reminiscence).

Study II was an attempt to learn more about these components of reaction time by relating them to everyday motor behavior. Teachers rated the poor readers of Study I on 15 questions dealing with abnormal motor behavior. The ratings were factor analyzed. Three factors were extracted and orthogonally rotated. The factors were interpreted as an Activity-Level Factor, an Attention-Span Factor, and a Motor-Coordination Factor. Correlations from the resulting factor scores and scores from the Reaction-Time Test were then examined. Neither of the components of reaction time identified above were related to the Activity-Level Factor. Early performance on the Reaction-Time Test, however, was significantly correlated with the Motor-Coordination Factor; and reminiscence, which is thought to measure the amount that performance declines during a series of massed trials, was significantly correlated with the Attention-Span Factor.

In Study III, the effect of methylphenidate on reaction times of hyperactive boys was studied. Hyperactive boys for whom pediatricians had prescribed methylphenidate were randomly divided into two groups. Both groups were given the Reaction-Time Test, except that medication was discontinued for one group two days before testing. A normal group matched on age and IQ was also tested. Performance of the hyperactive groups did not differ on early trials; and both hyperactive groups were slower than the normal group from the very beginning of the test. Performance-decrement, however, was larger for the off-medication group than for the normal and the on-medication groups.

Performance-decrement appears to be a measure of attention-

span. The significant correlation between reminiscence and the Attention-Span Factor found in Study II supports this interpretation. In addition, the interpretation is strengthened by evidence from Study III that methylphenidate, a drug commonly thought to improve attention, attenuated performance-decrement.

Reaction time on early trials appears to be a measure of response encoding speed, an ability which is depressed in reading-disability and hyperactive children. The results of Experiment III indicate that this ability is not sensitive to treatment by methylphenidate. The discussion section of this paper speculates on the importance of response encoding speed to perception span and short-term memory span, and therefore to reading.

Study I

Introduction

Performance typically declines during perceptual-motor and vigilance tasks, and recovers after rests. In addition, several studies have demonstrated greater decline and recovery for reading-disability children than for children of normal reading ability (Birch, 1967; Otto & Fredricks, 1963). In the studies comparing disabled and normal readers, two tasks were used. Birch used an auditory vigilance task, scored for accuracy. Otto used an inverted-digit-printing task, scored for speed. In these studies, however, early task performance did not differentiate the groups. Only after several minutes of continuous performance did group differences become significantly different. These results suggest that a gradual inhibition of performance may be at least partially responsible for reading disability. More specifically, Birch has suggested that it is the attentional response which is gradually inhibited.

Other studies have reported differences in the performance of poor and normal readers on a variety of tests involving discrimination and memory of auditory and visual stimuli. (For a recent review, see Samuels, 1971.) Typically, however, results are not reported separately for consecutive blocks of trials, therefore it is impossible to determine whether overall differences are reflected in initial as well as final trials.

The objective of the present study was to examine the relation between initial performance and performance-decrement in children of poor and normal reading ability. A same-different reaction time task was used. Children were required to respond to visually-presented pairs of letters by pressing one of two buttons, depending on whether the letters were the same or different. This task was used because it is highly efficient in discriminating poor and normal readers (Spring, 1971).

Method

Subjects

Poor readers (n = 22) and normal readers (n = 22) were selected from elementary schools. Each group contained eighteen boys and four girls. Groups were matched on age and IQ (WISC). Mean age was 10.1 years (SD = 1.2) for both groups. Mean IQ was 108 (SD = 10.7) for the disability group, and 111 (SD = 13.3) for the normal group. Although the groups did not differ significantly on total IQ, the disability group had significantly lower scores on the coding subtest: $F = 12.4$, $p < .005$. Poor readers were selected from learning-disability programs. Most of these child-

ren also had spelling problems, and several had mathematics problems. Children taking psychoactive medication, or with known sensory disorders, were excluded. Normal readers were drawn from regular classrooms, and were reading at, or above grade level. Cumulative school records were examined for comments indicating the presence of behavioral symptoms that might be related to reading disability. There were higher incidences, in the disability group, of comments indicating the following characteristics: immature motor ability ($\chi^2 = 11.86$, $p < .001$); hyperactivity ($\chi^2 = 4.83$, $p < .05$); and perceptual immaturity ($\chi^2 = 4.31$, $p < .05$).

Task

Two adjacent, upper-case letters were projected visually. Ss held microswitches in each hand, and were required to press the switch in their dominant hand if the letters were the same, and to press the switch in their non-dominant hand if the letters were different. Displays were not terminated until Ss responded.

Stimuli

Twenty letter-pairs were used. Half of these were "same" pairs, and half were "different" pairs. These letter pairs were repeated in each block of trials. Sequences, which were random, differed from block to block. A pair of letters subtended a visual angle of 0.5° from top to bottom, and 1.0° from left to right edge.

Procedure

Each session was divided into six blocks of 20 trials each, and was preceded by a practice block of 20 trials. A trial, which involved the presentation of a single pair of letters, required about five seconds. A ten-minute rest was scheduled between Blocks 4 and 5. During this rest, Ss were engaged in conversation. Instructions emphasized the importance of responding as fast as possible, and minimizing errors. Error feedback was given, and Ss were warned if errors became excessive. The sound of the projector provided a ready signal with a fixed fore-period of one second.

Results and Discussion

To remove the possibility that normal and poor readers might perform at different speeds as a consequence of accepting different error rates, one reading-disability S who made excessive errors was replaced. With this adjustment, mean error rate of the disability group was .072. Mean error rate of the normal group was .073. The difference was not significant.

Mean reaction time (RT), computed after discarding data from error trials, is shown in Figure 1 for Blocks 1 thorugh 6. The disability group was significantly slower than the normal group in every block: Block 1 ($F = 14.7$, $p < .001$); Block 2 ($F = 22.6$, $P < .001$); Block 3 ($F = 18.2$, $p < .001$); Block 4 ($F = 13.5$, $p < .001$); Block 5 ($F = 7.0$, $p < .025$); Block 6 ($F = 11.9$, $p < .005$). In addition, the disability group was significantly slower in the Practice Block ($F = 10.0$, $p < .005$).

Performance declined, from Block 1 to Block 4, about equally for both groups. An interpretation of performance-decrement during this period is difficult because it was impossible to avoid a half-minute rest between Blocks 2 and 3, during which slide trays were changed on the projector. This rest probably accounts for the slight recovery of RT between Blocks 2 and 3 by both groups. Following the 10-minute rest, recovery from Block 4 to Block 5, was significantly greater for the disability group ($F = 7.12$, $P < .025$). Subsequent decline of performance, from Block 5 to Block 6, was also significantly greater for the disability group ($F = 4.01$, $p = .05$).

The partial correlation of Initial RT and Performance-Decrement, with group membership held constant, was computed. Initial RT was defined as RT in Block 1. Performance-Decrement was defined as recovery from Blocks 4 to 5, plus decline from Blocks 5 to 6. Group membership was coded as a binary variable. The computed partial correlation between Initial RT and Performance-Decrement with group membership partialed out, $r = .19$, was not significant: $F(1,41) = 1.5$.

Three results emerged from Study I:

(1) Initial RT was significantly greater for poor readers.

(2) Performance-Decrement was significantly greater for poor readers.

(3) Although both Initial RT and Performance-Decrement were greater in the disability group, they were not significantly correlated after partialing out Group membership.

Study II

Introduction

This study deals with teachers' ratings of abnormal motor behavior in the group of poor readers tested in Study I. Among children with reading problems, unusually high frequencies of motor abnormalities are noted by observers such as teachers and pediatricians. These motor abnormalities, which are considered minor or "soft" neurological signs by some medical authorities, include poor fine-motor coordination, impaired perceptual-motor performance, and hyperactivity (Conners, 1967; Wender, 1971).

About nine months after administering the Reaction-Time Test described in Study I, teachers were asked to rate the poor readers from that study on fifteen inventory items dealing with abnormal motor behavior. The results were factor-analyzed. Correlations between the resulting factor scores and scores from the Reaction-Time Test were then examined. The purpose was to determine to what degree individual differences in the Reaction-Time Test covary with individual differences in every-day motor behavior that may be observed under non-laboratory conditions.

Two reaction-time scores were used. The first was Initial RT, the mean reaction-time during early trials of the Reaction-Time Test. The second score was the difference between mean reaction times immediately before and after the rest that was scheduled during the Reaction-Time Test (Reminiscence). Initial RT is thought to reflect individual differences in motor speed and control; therefore, it was expected that Initial RT would correlate significantly with a "motor-coordination" factor from the analysis of teachers' ratings. Reminiscense, on the other hand, is thought to reflect performance-decrement or the amount that performance declines during a series of massed trials; therefore, it was expected that Reminiscence would correlate significantly with an "attention-span" factor from the analysis of teachers ratings.

Method

Subjects

All of the poor readers available from Study I were included in Study II ($n = 21$).

Materials and Procedure

Ratings of abnormal motor behavior were obtained from a Motor Behavior Inventory mailed to the current teachers of the reading-disability children. The teachers were unaware of the scores obtained

by Ss on the Reaction-Time Test which had been administered about nine months earlier during the previous school year. The Motor Behavior Inventory contained fifteen items, which are shown in Table 1. Each learning-disability child was rated by his teacher on a four-point scale for each question. The scale ranged from "not at all like him" to "very much like him." Items in Table 1 are displayed in a sequence chosen for convenience in interpreting factors. The items were sequenced randomly, however, on the Motor Behavior Inventory completed by the teachers.

Results and Discussion

Intercorrelations of ratings on the 15 items of the Motor Behavior Inventory were calculated. Unities were placed in the principle diagonal and the resulting correlational matrix was then subjected to a principle components analysis. Three components, the last having an eigenvalue of 1.54, were then orthogonally rotated to approximate simple structure. The components selected for rotation accounted for 70 percent of the total variance. The Varimax method of rotation was used. Resulting factor loadings and communalities (h^2) are shown in Table 1. It may be seen that the communalities, or proportion of common factor variance in each item, are moderately high, indicating a moderately healthy condition for factor analysis. With the exception of items 6 and 10, communalities range from .62 to .88.

Interpretation of the resulting factors was straight forward. Factor I, with high negative loadings on items dealing with speed of motor behavior, and high positive loadings on items dealing with hypoactivity, was interpreted as an Activity-Level Factor. Factor II, with high negative loadings on items dealing with task persistence, and high positive loadings on items dealing with restless motor behavior, was interpreted as an Attention-Span Factor. Factor III, with high positive loadings on items dealing with fine motor coordination, was interpreted as a Motor-Coordination Factor.

As previously stated, we were interested in correlations of factor scores with scores from the Reaction-Time Test. It should be recalled, in evaluating the magnitude of these correlations, that there was a nine-month interval between the administration of the Reaction-Time Test and the Motor-Behavior Inventory from which factor scores were computed. No doubt correlations between reaction-time scores and factor scores are attentuated somewhat due to this long interval between tests.

Product-moment correlations between Initial RT and the three factors were computed. Initial RT was defined as the mean reaction time in Block 1. These correlations are shown in Table 2. In addition, correlations between Initial RT and individual items from the Motor-Behavior Inventory are shown in Table 2. As expected,

Initial RT was significantly correlated with the Motor-Coordination Factor (Factor III). Children rated by their teachers as most uncoordinated had the slowest reaction times during early trials of the Reaction-Time Test. Correlations between Initial RT and the Activity-Level and Attention-Span Factors (Factors I and II) however, were virtually zero. It may also be seen from Table 2 that Initial RT was significantly correlated with both items in the Motor-Coordination Factor, and that both of these items dealt with fine motor coordination. Initial RT, however, was not correlated with Item 7, which dealt with gross motor coordination, and had its largest loading on the Activity-Level Factor.

Product-moment correlations between Reminiscence and the three factors were also computed. Reminiscence was defined as mean reaction time in Block 4 minus mean reaction time in Block 5. These correlations, as well as correlations with individual items from the inventory, are also shown in Table 2. As expected, Reminiscence was significantly correlated with the Attention-Span Factor (Factor II). Children rated by their teachers as having the shortest attention spans had the largest Reminiscence scores in the Reaction-Time Test. Correlations between Reminiscence and the Activity-Level and Motor-Coordination Factors (Factors I and III) were not significant; although the correlation between Reminiscence and the Motor-Coordination Factor approached significance ($p < .10$; one-tailed test). It may also be seen from Table 2 that Reminiscence was significantly correlated with three items in the Attention-Span Factor: Items 8, 11, and 12. In addition, its correlations with Items 9 and 10 approached significance ($p < .10$; one-tailed test).

Study III

Introduction

Several studies have reported improved performance by learning-disability children, after treatment with stimulant medication such as dextroamphetamine (Dexedrine) and methylphenidate (Ritalin), on a variety of psychomotor tasks which discriminate disability and normal children. (For a recent review, see Conners, 1971.) Results, however, are not reported separately for consecutive blocks of trials, therefore it is impossible to determine if the effects of stimulant drugs are reflected in initial as well as final trials. For example, Sprague, Barnes, and Werry (1970) reported that RT was faster in a group of under-achieving, hyperactive boys after administration of methylphenidate. Their task, which was similar to that used in the present study, involved repeated blocks of trials. Data from initial and final trials, however, were not reported separately.

In a review of the effects of stimulant medications on the performance of normal adults, Weiss (1969) concluded that amphetamines help shorten RT in subjects fatigued by sleep deprivation, but that results of studies with unfatigued subjects have been negative more often than not. Assuming that similar brain changes underlie performance-decrement and fatigue, the possibility is suggested that (1) stimulants, including methylphenidate, reduce performance-decrement in learning-disability children, but (2) have no effect on initial RT. This possibility was examined in Study III.

To test this hypothesis, we identified hyperactive boys being treated by local pediatricians, and for whom methylphenidate had been prescribed. We then randomly divided these boys into two groups. The Reaction-Time Test was administered to boys in both groups; however, medication was discontinued 2 days before testing boys in one of the groups. This experimental manipulation was taken with the consent of parents and pediatricians.

An unusually high percentage of children with reading problems are described by their parents or teachers as hyperactive. See, for example, the high incidence of descriptions of hyperactivity found in the cumulative school records of the poor readers in Study I. Since populations of poor readers and hyperactive children do not overlap completely, however, it was thought necessary to again include a normal group in the comparisons. Thus, a second objective of Study III was to confirm that (1) initial RT would be greater for hyperactive boys not taking medication than for normal boys, and (2) performance-decrement would be greater for hyperactive boys not taking medication than for normal boys as well as hyperactive boys taking medication.

Method

Subjects

Three groups were tested. An on-medication group (n = 20) was composed of learning-disability boys who were taking methylphenidate, prescribed by their physicians. An off-medication group (n = 19) was composed of learning-disability boys who were also taking methylphenidate, but for whom medication was temporarily discontinued two days before testing. A normal group (n = 19) was composed of boys selected from elementary schools. Groups were matched on age and IQ (Peabody Picture Vocabulary). Mean age was 9.8 years (SD = 1.7) for the on-medication group; 9.9 years (SD = 1.7) for the off-medication group; and 10.0 years (SD = 1.8) for the normal group. Mean IQ was 107 (SD = 12.7) for the on-medication group; 108 (SD = 15.1) for the off-medication group; and 109 (SD = 17.8) for the normal group. The disability groups did not differ significantly on mean morning-dose of methylphenidate: 13.0 mg. (SD = 4.4) for the on-medication group; and 14.5 mg. (SD = 5.7) for the off-medication group. Disability groups also did not differ significantly on mean years of drug treatment: 1.78 years (SD = .98) for the on-medication group; and 1.52 years (SD = .88) for the off-medication group.

Task, Stimuli, Procedure

The task and stimuli were the same as those used in Study I. The procedure differed slightly. As before, there were six blocks of trials preceded by a practice block. The ten-minute rest, however, was scheduled between Blocks 3 and 4 instead of Blocks 4 and 5. This made it unnecessary to change slide trays on the projector until the scheduled ten-minute rest. All Ss were tested during mornings. Boys in the on-medication group received their normal morning dose of methylphenidate approximately 1 1/2 hours before reaction-time testing commenced.

Results and Discussion

To remove the possibility that groups might perform at different speeds as a consequence of accepting different error rates, two normal Ss who made excessive errors were replaced. With this adjustment, mean error rates of the groups did not differ significantly. Mean error rates were .079 for the on-medication group; .082 for the off-medication group; and .096 for the normal group.

Mean RTs, computed after discarding data from error trials, are shown in Figure 2 for Blocks 1 through 6. Distributions were severely skewed in the on-medication and off-medication groups; therefore, nonparametric Mann-Whitney one-tailed tests were used to analyze these data. Initial RT was defined as RT in Blocks 1 and 4 combined.

Final RT was defined as RT in Blocks 3 and 6 combined. Performance-Decrement was defined as decline from Blocks 1 to 3, plus recovery from Blocks 3 to 4, plus decline from Blocks 4 to 6.

The disability groups were not significantly different on Initial RT; however, the on-medication group was significantly faster than the off-medication group on Final RT. The normal group was significantly faster than both disability groups on Initial RT, as well as Final RT. Performance-Decrement was significantly larger in the off-medication group than in the on-medication and normal groups. Results are summarized in Table 3.

In Study III, methylphenidate had no effect on early performance in the on-medication group. As testing progressed, however, methylphenidate seemed to prevent excessive performance-decrement. These results should be considered tentative until a possible artifact is evaluated. A placebo was not used in Study II. One reason was that it was impractical to use a placebo with the normal group; and it was considered important to include a normal group in the study. Including a normal group made it possible to demonstrate that methylphenidate did not eliminate the difference between disability and normal boys on Initial RT, though it did eliminate the difference between on-medication and normal boys on Performance-Decrement. Another reason for not using a placebo was that switching boys in the off-medication group from methylphenidate to placebo, while leaving the other disability group on medication, might have created a placebo artifact, rather than correcting one. It is possible, however, that <u>discontinuing</u> medication in the off-medication group resulted in improved performance, due merely to the novelty of the change. If such an improvement actually occurred, methylphenidate may have affected Initial RT as well as Performance-Decrement; but its effect on Initial RT may have been obscured by the artifact. This seems unlikely, however. First, discontinuing the use of central stimulants by adults does not result in performance enhancement. On the contrary, discontinuance is often followed by a short period of depression and lethargy (Kalant, 1966). Second, medication was discontinued two days before testing, and the change was probably no longer novel.

Conclusions

Evidence from Study I that the performance of poor and normal readers differed on two components of RT was presented. The author believes that both components are involved in reading disability. Performance-decrement, which describes deterioration of performance over time, is believed to be a measure of attention span. Strauss and his associates have stressed that short attention-span is characteristic of children with learning disorders (Lewis, Strauss, & Lehtinen, 1960). This interpretation of performance-decrement as a measure of attention span is strengthened by the significant correlation reported in Study II between the Attention-Span Factor and Reminiscence. It is also strengthened by evidence from Study III that methylphenidate, a drug commonly thought to improve alertness, attentuated the rapid rate at which speed of hyperactive boys, declined as testing progressed, but did not effect speed during early trials.

The extraction of orthogonal Activity-Level and Attention-Span Factors in Study II is consistent with the suggestions of other investigators that the activity level of children is independent of their ability to engage in focused and directed behavior. The authors believe that the Attention-Span Factor reported here is an index of the ability to engage in focused, directed, and sustained behavior. Included in this factor were items dealing with task persistence, and items dealing with restless motor activity which the authors believe is a sign of avoidance behavior during performance of difficult tasks. The ability measured by this factor is apparently important to intellectual functioning. Maccoby worked with a general sample of nursery-school children and reported that the correlation of IQ with activity-level scores, measured by actometers, was essentially zero. She found, however, that the ability to inhibit movement under a task set that required inhibitation correlated significantly with IQ. From these results, Maccoby and her colleagues concluded that more intelligent children are characterized by activity which is directed, organized, and sequential, rather than by generalized inhibition of movement through their daily activities (Maccoby, Dowley, Hagen, & Degerman, 1965). Pope stated similar conclusions in a study comparing the motor behavior of learning-disability and normal children. She found no differences between the groups in total motor activity during periods of undirected activity or performance of a simple task. Differences did appear, however, during performance of a difficult task and during voluntary inhibition of activity (Pope, 1970). It may well be that "hyperkinetic behavior," so frequently reported as a symptom in learning-disability children, may describe the lack of focus and direction that characterizes their behavior more than the amount of their physical activity.

In addition to performance-decrement being greater for the

reading-disability group in Study I, the disabled children were also slower at the very beginning of testing. In fact, judging from distributions and F-ratios obtained from group comparisons, it is clear that Initial RT discriminated good and poor readers with greater efficiency than Performance-Decrement. In addition, in Study II a significant correlation was reported for poor readers between Initial RT and the Motor-Coordination Factor. These results suggest the importance to reading of an underlying response-encoding ability which may be impaired by various degrees in poor readers. The Reaction-Time Test used in the present studies is thought to be a rather direct measure of this basic ability. The test requires that a visual display of two letters be encoded into a two-choice response: press one key if the letters are the same, or the other if they are different. In this case, an overt motor response is required; although the required response might as easily be covert.

The importance of response encoding speed to reading is suggested by J. Mackworth (1971). In a series of studies, she found that different kinds of materials (digits, letters, colors, and figures) could be ordered according to the speed at which they are named aloud in free reading, presumably a measure of response encoding speed. She found the same rank order in the number of items that could be identified from very brief tachistoscopic presentations of these materials, concluding that encoding speed limits the rate at which items in a rapidly-decaying image can be identified and stored. She also found the same rank order in short-term memory span for these materials.

It seems reasonable that individual differences of motor-encoding speed would produce the same effects as differences in types of material produced in Mackworth's experiments. This hypothesis, which links motor ability to skill in perceiving and retaining verbal material, may explain why children who have slow reaction times, and who are clumsy, may be poor readers.

If response encoding speed is a critical factor in reading, the results reported in Study III must be interpreted as discouraging for it was found that hyperactive boys taking methylphenidate were as slow during initial trials of the Reaction-Time Test as hyperactive boys not taking the drug; and both groups of hyperactive boys were significantly slower than a normal group. As noted previously in this discussion, the drug did attenuate performance-decrement; and this was interpreted as improving attention-span. These results may explain the frequent clinical observation that stimulant medications often result in dramatic improvement of the restless behavior of hyperactive children without producing comparable gains in school achievement.

REFERENCES

Birch, R. W. Attention Span, Distractability and Inhibitory Potential in Good and Poor Readers. Ph.D. Dissertation, University of Wisconsin, 1967.

Conners, K. The syndrome of minimal brain dysfunction: psychological aspects. Pediatric Clinics of North America, 1967, 14, 749-765.

Conners, C. K. Drugs in management of children with learning disabilities. In L. Tarnopol (Ed.), Learning Disorders in Children. Boston: Little, Brown, and Company, 1971.

Kalant, L. J. The Amphetamines. University of Toronto Press: 1966.

Lewis, R. S., Strauss, A. A., & Lehtinen, L. E. The Other Child. New York: Grune and Stratton, 1960.

Maccoby, E., Dowley, E., Hagen, J., & Degerman, R. Activity level and intellectual functioning in normal preschool children. Child Development, 1965, 36, 761-770.

Mackworth, J. F. Some models of the reading process: learners and skilled readers. In F. Davis (Ed.), The Literature of Research in Reading with Emphasis on Models. Final report, Contract OEC-0-70-4790 (508), Project 0-9030. Graduate School of Education, Rutgers, 1971.

Otto, W., & Fredericks, R. C. Relationship of reactive inhibition to reading skill attainment. Journal of Educational Psychology, 1963, 54, 227-230.

Pope, L. Motor activity in brain-injured children. American Journal of Orthopsychiatry, 1970, 40, 783-794.

Samuels, S. J. Success and failure in learning to read: a critique of the research. In F. Davis (Ed.), The Literature of Research in Reading with Emphasis on Models. Final report, Contract OEC-0-70-4790 (508), Project 0-9030. Graduate School of Education, Rutgers, 1971.

Sprague, R. L., Barnes, K. R., & Werry, J. S. Methylphenidate and thioridazine: learning, reaction time, activity, and classroom behavior in disturbed children. American Journal of Orthopsychiatry, 1970, 40(4), 615-628.

Spring, C. Perceptual speed in poor readers. Journal of Educational Psychology, 1971, 62, 492-500.

Weiss, B. Enhancement of performance by amphetamine-like drugs. In F. Sjoqvist and M. Tottie (Eds.), Abuse of Central Stimulants. Stockholm: Almqvist & Wiksell, 1969.

Wender, P. Minimal Brain Dysfunction in Children. New York: John Wiley and Sons, 1971.

TABLE 1

Rotated Factor Loadings and Communalities ($\underline{h}^2$)

Item	Factors			$\underline{h}^2$
	I	II	III	
1. Talks rapidly.	-.85*	.06	.39	.88
2. Hard to slow down.	-.82*	.36	.22	.85
3. Usually walks rapidly.	-.76*	.29	.04	.67
4. Runs, jumps, skips less.	.74*	.28	.49	.87
5. Moves slowly.	.71*	-.06	.40	.67
6. Prefers non-physical games.	.66*	.01	.34	.56
7. Looks uncoordinated walking, running.	.81*	.26	.35	.85
8. Reluctant to leave a job.	-.17	-.84*	-.14	.75
9. Works long time to finish assignments.	.06	-.80*	.21	.69
10. Tries again if unsuccessful.	.01	-.56*	-.03	.32
11. Twists, turns in seat often.	-.18	.80*	.24	.73
12. Leaves seat more than most.	-.08	.75*	.27	.64
13. Frequently shifts hands and feet.	-.12	.71*	.30	.62
14. Has poor handwriting for age.	.09	.15	.88*	.81
15. Clumsy handling small objects.	.13	.23	.77*	.66

*Loadings greater than .50

TABLE 2

Correlations of Factor and Item Scores With Initial RT and Reminiscence

Item	Initial RT	Reminiscence
Factor I: Activity Level	-.06	-.20
1. Talks rapidly.	.25	.40*
2. Hard to slow down.	-.05	.31
3. Usually walks rapidly.	.19	.08
4. Runs, jumps, skips less.	.23	.13
5. Moves slowly.	.03	-.32
6. Prefers non-physical games.	.08	.11
7. Looks uncoordinated walking, running.	.15	-.02
Factor II: Attention Span	.01	.41*
8. Reluctant to leave a job.	-.22	-.38*
9. Works long time to finish assignments.	.14	-.33
10. Tries again if unsuccessful.	.12	-.31
11. Twists, turns in seat often.	.28	.44**
12. Leaves seat more than most.	-.04	.47**
13. Frequently shifts hands and feet.	.27	.29
Factor III: Motor Coordination	.55***	.33
14. Has poor handwriting for age.	.55***	.45**
15. Clumsy handling small objects.	.49**	.36

* $p < .05$

** $p < .025$

*** $p < .005$

TABLE 3

Mann-Whitney Tests*

of Drug Effects

Test	Initial RT	Final RT	Performance-Decrement
On-Med > Normal	$p < .025$	$p < .025$	N.S.
Off-Med > Normal	$p < .01$	$p < .001$	$p < .01$
Off-Med > On-Med	N.S.	$p < .05$	$p < .025$

*One-tailed tests

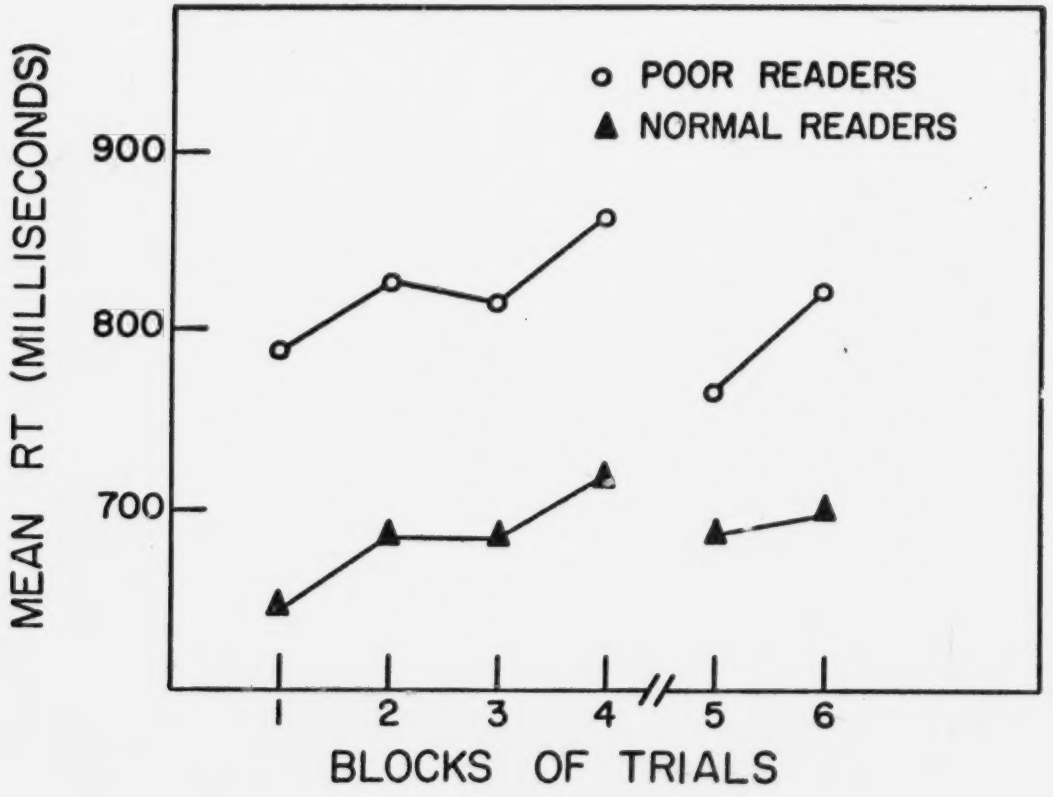
POOR READERS
NORMAL READERS
MEAN RT (MILLISECONDS)
900
800
700
1
2
3
4
5
6
BLOCKS OF TRIALS

Figure 1

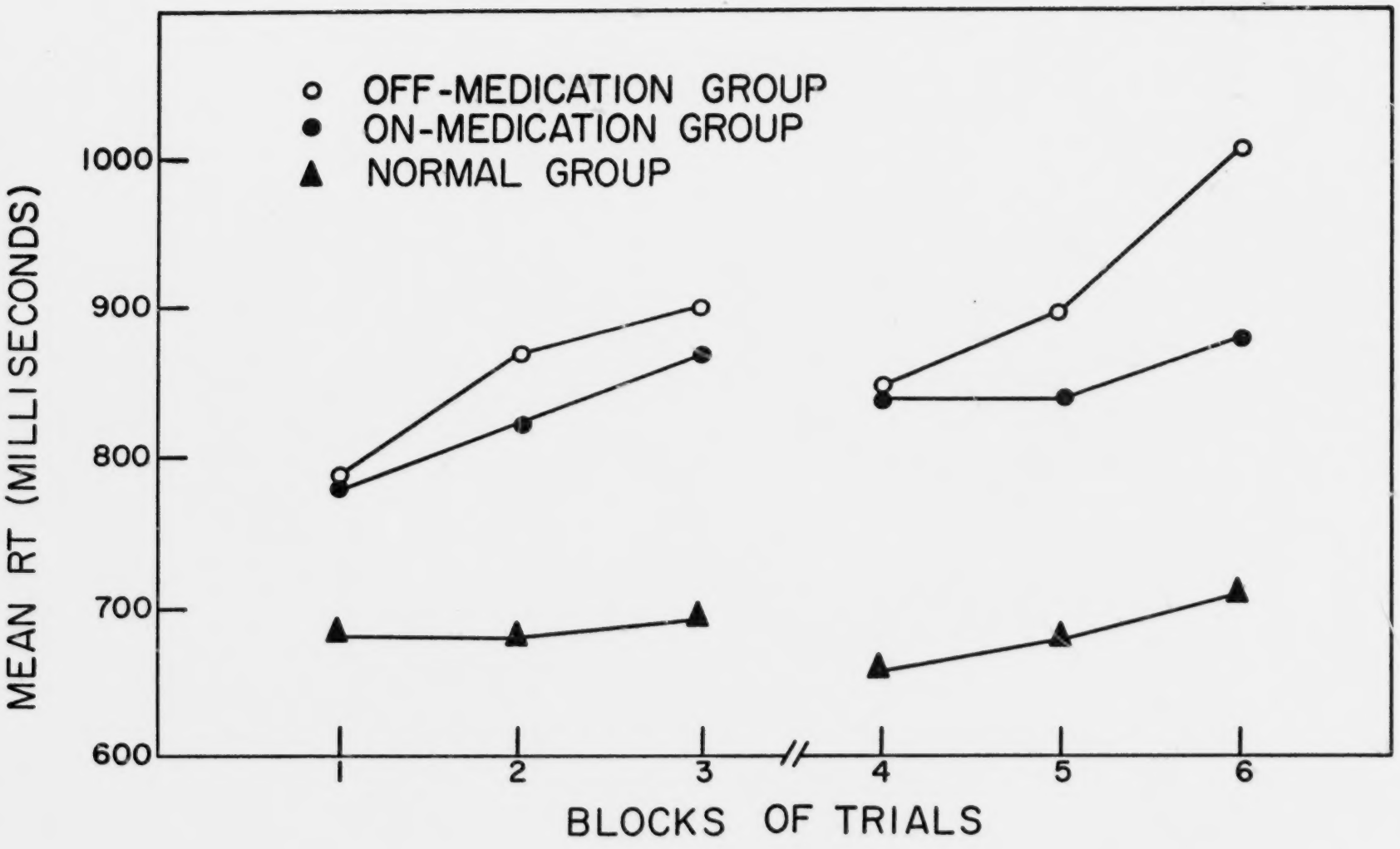
OFF-MEDICATION GROUP
ON-MEDICATION GROUP
NORMAL GROUP
MEAN RT (MILLISECONDS)
1000
900
800
700
600
1
2
3
4
5
6
BLOCKS OF TRIALS

Figure 2